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Frost was, as R. Tucker writes, a great favorite at Cambridge, a sure concomitant of his brightness, cheerfulness, kindness of heart and consideration for others.

His exceptional life-long experience gives tremendous weight to his testimony in favor of the early cultivation of a talent for mathematics.

He explicitly says : "To attempt after a certain age to acquire ease in mathematical operations is like a grown man trying to learn the violin."

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SOME REMINISCENCES IN REGARD TO SOPHUS LIE.

By DR. G. A. MILLER.

Since the death of the famous Norwegian mathematician, Sophus Lie, a large number of appreciative articles on his life and work have appeared in the mathematical journals of various countries. Two such articles were published in the April number of this journal. In what follows we shall endeavor to add a few details (based upon personal observations) which may assist those who never met him to form a more accurate idea with respect to him.

The trait of Lie's character which impressed me most forcibly when I first met him in the summer of 1895 was his extreme openness and lack of effort to hide ignorance on any subject. It is well known that he began the study of discontinuous groups under the masterly guidance of Sylow. He maintained a deep interest in these groups, making frequent use of Jordan's classical "Traité des Substitutions," and he spoke in terms of great respect of the work of Jordan, Frobenius, and others who were working in the field of discontinuous groups.

He, however, never felt at home in this subject. In fact he frequently remarked during his lectures that he always got stuck when he entered upon the subject of discontinuous groups, To him the continuous groups seemed more simple as well as more useful. He frequently used the expression, "the disconuous groups are good but my (continuous) groups are better," and he advised his students to begin their study of groups with the continuous groups and to take up the study of the discontinuous groups later.

He was an inspiring teacher but his lectures were not always well prepared. Sometimes he had to pay quite heavily for this lack of preparation, being unable at the moment to prove simple things in his own theory. It was an interesting sight to see him at the board working away with all his might and calling on his students to help him out of the difficulty, using the expression, "Here I stick, will not one of you help me out." He kept in good spirits at such occasions but he generally could not maintain enough self-possession to work his way out of the difficulties during the rest of the hour.

He was somewhat careless in regard to his dress. If he felt uncomfortable he would take off his collar and tie before his class, lay them aside, and then go on with his lecture. At one time the room happened to be somewhat cold so he put on his big hat and kept in on during the entire lecture. He considered his lectures as gymnastics for the students, being bent on training them to think according to his methods rather than on giving them a systematic treatise on any subject.

In his intercourse with the students he was friendly and approachable. He seemed to pay special attention to foreign students, claiming that they were generally better prepared than his German students. He would talk for hours with foreign students, asking questions in regard to their work as well as in regard to the mathematicians of their country. In case a student was well acquainted with any mathematical subject he would ask questions in regard to details which were unknown to him, candidly stating that he was asking for information.

During the summers of 1895 and 1896 he returned from his summer vacation about one month before the opening of the university and lectured daily before the few American students of mathematics who happened to be in Leipzig, with a view to prepare them to follow his lectures better during the university year. He did this work gratis and at his own suggestion. These lectures were very elementary and frequently took the form of a colloquium, the aim being to make the student familiar with the mathematical phrases rather than to teach much mathematics.

An idea of his view of mathematics in general may be inferred from the following incident. The building in which he held most of his lectures was royal property and the king of Saxony lived in a part of it whenever he came to Leipzig. One day Lie remarked to a few Americans, "Perhaps you do not know that our rooms are in the royal palace. It seems to me very appropriate that mathematics should be taught in a royal palace for it certainly is a royal subject. In some of the other departments one generation discards what the preceding generation regarded as established facts, but in mathematics an established fact remains valuable forever. We have just as much admiration for mathematical facts that were proved 2000 years ago as for those which have been established during our generation.

"Mathematics is a royal subject but the trouble is that the mathematicians do not get royal pay. Some of the professors here who lecture on popular subjects get several thousand dollars per year in students' fees, while the mathematician gets scarcely anything beyond his regular salary. In the popular departments the advanced subjects are frequently assigned to the younger men while the professors lecture on the elementary subjects in order to increase their income. In mathematics we are not tempted to commit this sin since all of our classes are small."

Lie was regarded as one of the easiest men at Leipzig for the doctor thesis. He generally assigned easy subjects and he assisted the students very freely. He was a hard worker, working seven days per week. He used to say that he was almost certain to make mistakes in going over a piece of work for the first time, and that he could generally not find his errors until he would work over the problem a second time using different symbols. He frequently got very enthusiastic over the theory of groups remarking (not very seriously) that everything could be done by means of groups.

The students talked a great deal about his peculiarities but they had great respect for his attainments. In speaking about Klein and Lie, a Frenchman who had studied under both remarked, "Klein is a gentleman while Lie is just a good fellow." I presume many of those who studied under both would agree that this statement conveys a great deal of truth.

I feel encouraged to publish these few personal observations because I believe that Lie would have liked to have his faults go with his merits. I do not think he wanted to be regarded as one who thought that he had mastered every part of the extensive science of mathematics or as one who thought that all his habits were exemplary. He believed that he had contributed materially towards the advancement of the science of mathematics and he worked hard to accomplish this end. Future developments along the lines which have been emphasized or opened by him will have a great influence on his relative position among the mathematicians of this century.

Cornell University, June, 1899.

AN ELEMENTARY EXPOSITION OF GRASSMANN'S "AUSDEHNUNGSLEHRE," OR THEORY OF EXTENSION.

By JOS. V. COLLINS, Ph. D., Stevens Point, Wis.

Grassmann's *Ausdehnungslehre* is one of the few great works of mathematics of the 19th century. Appearing first in 1844 and rewritten in 1862, it is only within the last decade or two that it has received a tardy recognition. One reason for this is found in the difficulty of the subject itself, being unlike other mathematics ; and another, in the rigorous methods of presentation adopted by the author. In the *Ausdehnungslehre* of 1862, following some 150 pages of theory, the author for the first time gives the subject concrete form by applying his method to geometry. The theoretical part is naturally the more difficult, while the application to geometry is the more interesting. Hyde, in his *Directional Calculus*, purposing to present the *Ausdehnungslehre* to American readers, cut the knot of the difficulty by taking the results of the theoretical part for granted and giving only the application to geometry, and by limiting his treatment to two and three dimensional space.

An elementary exposition which will give the simpler portions of the theoretical part as well as the applications of the theory seems to be needed.